VEGETABLES FOR THE HOT, HUMID TROPICS

Part 7. The Peppers, *Capsicum* Species

Science and Education Administration
U.S. Department of Agriculture

PREFACE

In the hot, humid Tropics, torrential rains during the monsoon create special hazards for agriculture. Lands are muddied or flooded, entrance to plantings is restricted, weeds grow vigorously, chemicals applied are washed from the plants, and fertilizer is leached from the soil. High water tables drive oxygen from the soil, diseases thrive above and within the soil, and many plants are uneconomical to cultivate. These conditions make food production difficult, and agricultural skills imperative.

During tropical rainy seasons, the problem of producing highly nourishing food still exists. For the most part, the solution is to select appropriate species and varieties and know how to grow and utilize them in both conventional and unconventional ways.

Tropical diets are often unbalanced not only because of ignorance of sound dietary principles and because of food prejudices, but also because of a lack of good species and varieties. The Tropics are exceedingly varied in this respect, but knowledge is inadequate almost everywhere. Furthermore, even when appropriate varieties are known, it is often difficult to obtain seeds.

The purpose of this series of bulletins is to furnish information about vegetables that can be grown in the hot, humid Tropics. The vegetables covered are either not well known, at least with respect to some uses, or not well distributed, but are productive during tropical rainy seasons. The techniques recommended can be applied on a small scale or with a low level of technology. Seed sources are suggested when necessary.

VEGETABLES FOR THE HOT, HUMID TROPICS

Part 7. The Peppers, *Capsicum* Series

By FRANKLIN W. MARTIN, JOSÉ SANTIAGO, and A. A. COOK[1]

INTRODUCTION

Among the nonfarinaceous vegetables of the hot, humid Tropics probably no fruit vegetable has as many advantages as the peppers, especially *Capsicum annuum*. Peppers are hot weather vegetables. They can be grown anywhere in the Tropics, at any time of the year except in high mountainous regions with alpine climates. Peppers are highly nutritious, and because of their wide variety of forms (fig. 1), can be used as a food in many ways. They are attractive and acceptable in taste to almost everyone. Furthermore, they can often be produced with a minimum of problems with pests and diseases.

Peppers are already widely used throughout the Tropics, but newly developed disease-resistant, long-lived varieties that can withstand tropical monsoons are well distributed. There is a need for an increased appreciation of each form and the many uses and nutritional value of peppers and a better distribution of available varieties.

---

[1]Horticulturist and agricultural research technician, Mayagüez Institute of Tropical Agriculture, Science and Education Administration, U.S. Department of Agriculture, P.O. Box 70, Mayagüez, P.R. 00708, and plant pathologist, University of Florida, Gainesville, Fla. 32611.

FIGURE 2.—Bell pepp

There are many cultivated forms of *C. annuum*. The morphology of the fruit and its pungency has often been used to identify types of peppers, and this has sometimes led to considerable confusion, especially since all forms intergrade and can interbreed freely. Morphological forms should not be confused with botanical varieties. The most common forms are:

Long peppers—usually 20 to 30 cm long, cream, yellow, or red in color, tapering.
Sweet, bell, and paprika peppers (fig. 2)—large, inflated, thick-fleshed fruits.
Chili peppers—over 9 cm long, narrow, pointed.
Wrinkled peppers—less than 5 cm long, wrinkled appearance.
Cherry peppers—globose with firm flesh, yellow, red, or violet (fig. 3).
Cone or tabasco peppers—small conical, erect fruits.
Cluster peppers—fruits borne in clusters.

The common names for peppers usually consist of adjectives modifying the word pepper. Some reference to pungency (or lack of it) is frequently included. Common modifiers include bell, bird, capsicum, cayenne, chili, paprika, pimento, red, sweet, and wax.

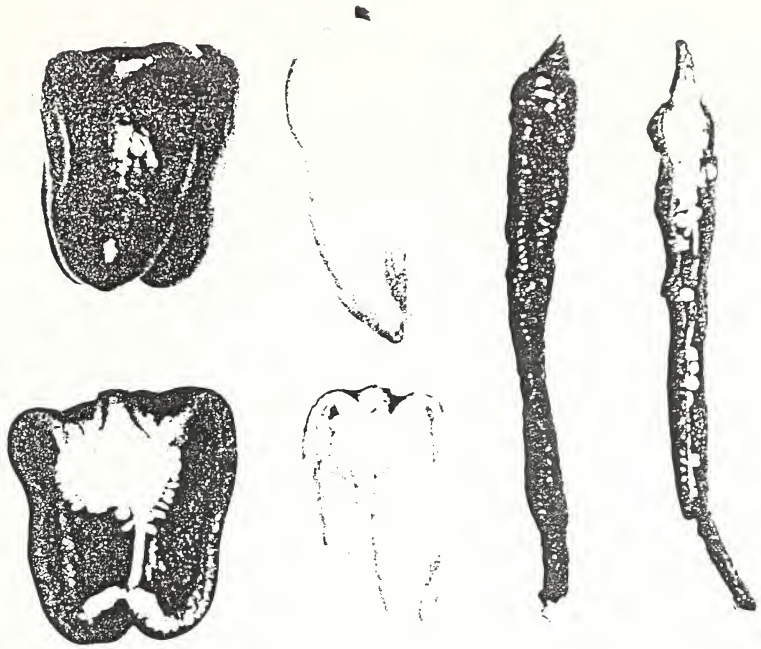

FIGURE 4. — Exterior and interior of three pepper types: stuffing, mild condiment, and strong condiment.

new branches arise at each node. One branch never develops, but bracts are attached to the stem through the distance to the next node. The stem thus appears to be dichotomously branched at each node. This trait also influences the inflorescence, which is actually terminal, but because of the branching habit appears to be in leaf axils at the node. Only careful examination of the growing pattern makes these distinctions clear.

The leaves are alternate, simple, ovate or sometimes almost lanceolate, and have entire margins. They are thin and almost glabrous and their size varies considerably. The tip is acuminate and the base acute or cuneate. The inflorescence usually consists of a single flower with a five-parted campanulate calyx that may continue to grow after pollination and may partially enclose the fruit. The corolla is seldom more than 15 millimeters in diameter, slightly campanulate, divided into five or six petals, and whitish or greenish in color. The five or six anthers that occur on short filaments dehisce longitudinally. The style is simple and bears a capitate stigma. The fruit is a hollow, oblate to very long berry having two or more locules and varying in both immature and mature color (fig. 4).

FIGURE 5 — A dete
type waxy pepper wit
centrated fruit yield

resistance is available, and which is usually included in breeding program objectives is bacterial leaf spot caused by *Xanthomonas versicatoria*. Some varieties are also resistant to attack by corn borers (*Ostrinia* spp.).

Considerable interest has been expressed in hybrid varieties. If parents are well chosen, hybrids show considerable heterosis (growth or yield superior to the parents). Hybridization also allows seed companies to sell unique varieties that cannot be propagated from their own seed. Use of cytoplasmic male sterility permits more rapid pollinization and cheaper hybrid seed.

Most breeding efforts in the United States focus on the size and shape of bell peppers used as a salad crop or for stuffing, but attention is now being given to other pepper forms including tabasco, cherry, and various classes of chili peppers. The disease resistances being incorporated in bell peppers are useful in these other varieties. Chili peppers are also bred for capsaicin content, color, firmness, and vitamin content.

There is presently much interest in breeding peppers for machine harvesting, especially in the case of "industrialized" peppers (peppers for canning or condiment manufacturing). Machines have been used successfully only with certain types of peppers. Machine-harvested varieties must produce and mature all fruits almost simultaneously since all fruits are picked at once. Fortunately, most pepper fruits maintain their quality on

TABLE 2.—*Some peppers that have been selected for Puerto Rican growing conditions*

Varietal name	Type of pepper	Source	Fruit weight (g)	Yield (tonnes/ha)[1]	Pungency	Outstanding characteristics
'Agronomico 106'	Bell	Brazil	29	4.6	None	Virus resistance.
'Aromatic Chili'	Chili	Hungary	8	9.7	Strong	Heavy production, long life.
'Bigheart'	Bell	Israel	46	4.8	None	Good fruit type.
'Blanco del Pais'	Sweet	Puerto Rico	24	6.0	None	Reliable, heavy production, long life
'Cubannelle'	Sweet	Puerto Rico	29	3.9	None	Reliable.
'Delray Bell'	Bell	Florida	47	3.5	None	Broad virus resistance.
'Early Pimento 6088–9'.	Sweet, heart-shaped.	U.S.A.	24	12.2	None	Heavy production.
'Ensalada'[2]	Miscellaneous	Puerto Rico	2	7.7	Mild	Long life, edible leaves.
'Hungarian Bell'[2]	Bell	Hungary	26	3.7	Mild	Uniform shape and size.
'Pimiento Rojo'[2]	Chili	Hungary	22	8.1	Strong	Heavy production.
'P.R. Wonder'[3]	Bell	Puerto Rico	24	2.9	None	Tropical adaptation.
'VR–2'	Bell	Florida	94	3.1	None	Virus resistance, very large fruits.
'White Flood'	Wax	Hungary	43	5.4	Mild	Determinate, high yields
'Yolo Y'	Bell	Florida	41	2.7	None	Good fruit type, fairly reliable

[1] Winter trial.

[2] Names assigned. No other names known.

[3] Pérez (5) obtained yields of up to 42 tonnes/hectare with this variety in Puerto Rico.

mercial plantings a nematicide or soil fumigant is often applied after plowing. Ridges or furrows should be prepared with a height (or depth) of 25 centimeters. If seeds are to be planted directly, the seedbed should be carefully smoothed and all clods finely broken. Fertilizer should be added before planting, usually applied mechanically as a band below and to the side of the area where the plants will be placed. Type of fertilizer and rate of application will depend on local soil requirements.

Direct seeding usually results in higher and earlier yields. From 110 to 160 seeds are found to the gram. Stored under cool, dry conditions, they remain viable for several years. Two kilograms of seed are needed per hectare.

For later transplanting, seeds are planted 5 to 6 centimeters apart, 1 to 3 seeds per site, or can be placed in an almost continuous line, in furrows 5 to 8 centimeters apart and 0.5 to 1 centimeter deep. They are covered with a fine soil mix or sand, and thoroughly watered. If flats are protected from direct sun and excessive heat, the seeds may germinate without further watering.

If plants are to be established in pots or flats, the soil mixture should include equal parts of sand, loam, and manure or compost. Soil should be sterilized by heating it in an oven or treating it with boiling water or steam.

Transplanting

Seedlings are thinned or transplanted to other flats of soil once they have produced two true leaves. They are carefully uprooted with a small stick, and placed in holes in flats of soil at 5 to 6 centimeter intervals. Plants must not dry out during transplanting, and flats of transplanted plants need to be watered almost immediately. Careful attention should be given seedlings at every step. Watering should be adequate but not excessive. Pepper seedlings are more sensitive and demanding than tomatoes. Seedlings are sometimes watered once or twice with a "starter solution" (5 grams soluble complete mineral fertilizer per liter of water). Seedlings can be treated with fungicides and insecticides to reduce seedling loss, but this must be done according to local legal restrictions on pesticide use.

When the plants are 6 to 8 centimeters high, hardening should begin; flats are exposed to progressively drier and sunnier conditions and to the high or low temperatures expected in the field. Growth slows and the plants lose their succulence. Hardening continues for about a week, after which the plants are ready for transplanting. Several days before planting, a knife is passed through the flats of soil to separate the plants, and each

India (2), nitrogen increased vegetative growth and time to flower, phosphorus decreased time to flower, and maximum yields were obtained with 250 kilograms per hectare each of nitrogen and phosphorus. In Puerto Rico, Pérez successfully used a sidedressing of 1,120 kilograms per hectare of 5–10–10 fertilizer. Some plots also received 280 kilograms per hectare of ammonium sulfate, applied when flowering began and after the first harvest.

Peppers are sometimes treated with various other substances during growth to control pests or regulate growth. But application of growth regulators is not yet a standard practice, and such treatments must be legally registered. Ethephon, applied as a spray, has been proposed as a treatment for paprika- or pimento-type peppers (*10*) to help color the fruits uniformly.

PESTS AND DISEASES

Viruses are particularly serious diseases of peppers in all parts of the Tropics. At least five viruses attack peppers, tobacco mosaic virus (TMV), tobacco etch virus (TEV), potato y virus (PYV), pepper mottle virus (PeMV), cucumber mosaic virus (CMV), and pepper veinal mottle virus (PVMV). All these viruses can be transferred mechanically and all but TMV can be transferred by insects. Since all viruses have common alternate hosts, potential sources of infection are frequent. But not all viruses occur in all areas, and in any one area it is often difficult to determine what viruses are present on the basis of symptoms alone. Symptoms of viruses include mottling, twisting, and distortion of leaves, reduced leaf width or size, and stunting of growth.

TABLE 3.—*Varieties of bell pepper resistant to common pepper viruses*

Varietal name	Tobacco mosaic	Tobacco etch	Potato y	Pepper mottle	Cucumber mosaic
'Agronomico 4'	S	S	R	S	S
'Algert'	R	S	S	R	S
'Avelar'	R	S	R	R	S
'Delray Bell'	S	R	R	R	S
'Early Cal Wonder'	S	S	S	S	S
'Florida VR–2'	R	R	R	S	S
'Yolo Wonder'	R	S	S	S	S
'Yolo Y'	R	S	R	S	S

R, resistant. S, susceptible.

seasons of high rainfall, drastically reduce fruit set and fruit quality. Some peppers may be resistant to this disease, and resistance is being bred into peppers now being developed. Other control methods are crop rotation, not planting peppers and tomatoes together, and use of copper or other bactericidal sprays.

Another disease of peppers is phoma rot (*Phoma destructiva* Plowright), seen as a gradually enlarging series of concentric rings on the leaves and stem. The lesion on the fruit is small, depressed, near the stem end, and may contain small black specks. Phoma rot is avoided by destroying infected plant materials and planting only in clean seedbeds. Plants may also be treated with fungicidal sprays.

Still another fruit rot is caused by *Vermicularia capsici* Sydow, which occurs on the fruit as a series of small sunken spots with prominent black specks, and is not ordinarily seen on the foliage. Infected fruits should be removed and destroyed, since the disease is transferred from one fruit to another or is carried by the seed of an infected fruit. This fruit rot is also controlled by fungicidal sprays.

A leaf spot disease seen as round, whitish spots with dark margins is caused by *Cercospora capsici* Heald & Wolf. It develops rapidly, defoliates leaves, and can damage a planting seriously. All diseased parts should be burned. Fungicidal sprays are also used.

Very few insect pests have been seen in Puerto Rico, even in fields untreated with insecticides. The most damaging pest (often severe in greenhouses and home gardens but less of a problem in commercial plantings) is the previously mentioned white mite, *Hemitarsonemus latus*. In India another important pest is *Scirtothrips dorsalis* H., a species of thrips, and in Florida, the corn earworm, *Heliothis zea* (Boddie), and the pepper weevil, *Anthemomus eugenii* Cano, are common problems.

HARVEST AND YIELDS

When peppers are harvested depends on the variety and how they are going to be used. Bell peppers and other peppers for stuffing are usually harvested when large but still immature. Such practice reduces the likelihood of fruit rot, but the fruits are equally useful and more nutritious when they are fully ripened. Pimento peppers, appreciated for their bright red colors, are normally harvested when completely red. Peppers for pickling (including small cherry types) are harvested green or ripe. Very pungent peppers used as a condiment are usually harvested red

ground to provide the condiment, red pepper, and liquid hot sauce is made by pickling or fermenting fresh fruits.

Chili pepper is included in laying mixtures for hens because of its high carotene content. This makes both the eggs and the fat of the animal much more yellow. Peppers are also used in internal and external folk medicines.

Composition

The compositions of green and mature bell pepper fruits are given in table 4. Nutritionally the outstanding components are vitamin C and (when ripe) vitamin A. The needs of the average person for vitamin C could easily be supplied by eating 100 to 200 grams of bell or sweet pepper each day. If the peppers are eaten when fully mature much, if not all, of the vitamin A needed daily could also be obtained. Provitamin A contents are higher in dark-green fruits than in light-green or yellow fruits, and vary considerably among varieties. Pungent peppers used as condiment are unlikely to make a nutritional contribution unless formidable quantities (100 grams) are eaten daily.

Other nutrients supplied by peppers do not occur in quantities that are nutritionally significant. The iron and B-vitamin contents are only average, and fat, carbohydrate, and protein occur only at low levels.

TABLE 4.—*Composition of bell pepper fruits*

[Per 100 grams of edible portion]

Fraction		Green	Mature
Principal components:			
Water	g	93.4	90.7
Protein	g	1.2	1.4
Carbohydrate	g	4.8	7.1
Fat	g	0.2	0.3
Minerals:			
Calcium	mg	9	13
Iron	mg	0.7	0.6
Phosphorus	mg	22	30
Vitamins:			
Ascorbic acid (vitamin C)	mg	128	204
Carotene (provitamin A)	IU	420	4450
Niacin (vitamin B_3)	mg	0.5	0.5
Riboflavin (vitamin B_2)	mg	0.08	0.08
Thiamine (vitamin B_1)	mg	0.08	0.08

Source: Adams (*1*).

PROSPECTS FOR THE FUTURE

Peppers are assured a successful future; they are already popular in the diet and their use widespread. Excellent, disease-free varieties are already available, but they have not been universally adopted. The improvements constantly being made by plant breeders assure varieties that will be easier to grow with less disease and higher yields. But emphasis on compact, determinate varieties for machine harvesting should not hamper the development of long-lived varieties for home-scale production. It should be simple to breed such varieties; the necessary characteristics are already present in *C. annuum*. The considerable variation in carotene and vitamin C content also afford ample opportunity to select more nutritious varieties.

The use of peppers as processed vegetables could increase. The pungent peppers are already widely used in this fashion. And since the peppers used green are not as rich in vitamins as the yellow or red mature forms, peppers can contribute more to the diet if people merely change their usage habits.

LITERATURE CITED

(1) Adams, C. F. 1975. Nutritive value of American foods in common units. U.S. Dep. Agric., Agric. Handb. 456, 291 pp.

(2) Gill, H. S., Thakur, P. C., and Thakur, T. C. 1974. Effect of nitrogen and phosphorus application on seed yield of sweet pepper, *Capsicum annuum* L. Indian J. Hortic. 31(1): 74–78.

(3) Heiser, C. B., and Smith, P. G. 1953. The cultivated *Capsicum* peppers. Econ. Bot. 7: 214–227.

(4) Lippert, L. F., Smith, P., and Bergh, B. O. 1966. Cytogenetics of the vegetable crops. Garden pepper, *Capsicum* spp. Bot. Rev. 32: 24–55.

(5) Pérez-Serrano, A. C. 1977. Yields of sweet pepper (*Capsicum annuum*) cultivars in northwestern Puerto Rico. J. Agric. Univ. P.R. 61: 90–99.

(6) Pochard, E. 1977. Localization of genes in *Capsicum annuum* L. by trisomic analysis. Ann. Amelior. Plant. 27: 255–267.

(7) Thenabadu, M. W., Jaufer, M. M. M., and Haniffa, M. 1974. Fertilizer experiments with chilli (*Capsicum annuum*) at Gannoruwa. Trop. Agric. (Sri Lanka) 130(1): 45–51.

(8) Thompson, H. C. 1939. Vegetable crops. 578 pp. McGraw-Hill, New York.

(9) Vargas-Ramírez, L. G., Loria-Martínez, W., Pérez-Arguedas, O. A. 1976. Estac. Exp. Agric. Fabio Baudrit M. Bol. Tec. 9(1), 17 pp.

(10) Worku, Z., Herner, R. C., and Carolus, R. L. 1975. Effect of stage of ripening and ethephon treatment on color content of paprika pepper. Sci. Hortic. 3: 239–245.

☆U.S. GOVERNMENT PRINTING OFFICE: 1979-671-037/6A

With peppers that are harvested green, harvesting regularly every week or two is generally sufficient. Some varieties can be picked over an extended period, occasionally a year or more. Most commercial peppers are harvested for about 3 months, or until disease begins to take its toll or plants lose vigor. Picking once only is the ideal for machine-harvested varieties. This is easier to do with chilis and other peppers that remain ripe on the plant for long periods of time, but green peppers (including the bell type) are now being bred that can be harvested only once by machine. Maximum yields of green peppers reach 40 tonnes per hectare and of condiment peppers about 35 tonnes per hectare. Even higher yields have been obtained by Pérez (*5*) in Puerto Rico.

Once harvested, green peppers should be removed from the sun, sized and sorted as quickly as possible, then stored at cool temperatures. They can be stored for as much as 40 days at 0° C and 95 to 98 percent relative humidity (*8*). Peppers will not freeze at 0° C. Chili peppers are often hung to dry, left exposed to the sun, or dried in a drying cabinet or oven.

UTILIZATION AND NUTRITION

Uses

Peppers are one of the most versatile vegetables for the hot, humid Tropics. In the Western World the most commonly used pepper is the bell or paprika type, harvested while still green. The raw green fruits are sliced into rings, cut into strips or diced and mixed with relish, or are stuffed with mixtures (often including meat) and baked.

Probably the principal use made of peppers in the rest of the world is as a condiment; peppers are valued for their pungent qualities. Many persons who cannot endure the violent pungency of the hottest peppers or of their sauces can still appreciate the light pungency of the mildest varieties, or that which is achieved when only a little hot pepper is added to a dish. The familiar chili con carne, for instance, is a popular dish in which peppers are used, but not to their maximum capacity. Tolerance of pungency is a learned ability; once it is acquired, food without chilis is not tasty.

There are also common minor uses of the fruits, one of the most important of which is as a pickle, sweet, mild, or very pungent. Pickling in brine is a simple way to preserve large amounts of this vegetable until needed. In some regions pickling in vinegar (at times mixed with sliced tomatoes and other vegetables) is common. The very hot peppers, when dried, are

Although some control of viruses can be obtained through cultural practices (avoiding other possible hosts, especially solanaceous and cucurbitaceous plants, and avoiding handling healthy plants after touching diseased plants or after using tobacco), the best virus control is achieved by using resistant varieties. Some virus-resistant varieties are given in table 3.

In addition to virus symptoms, peppers may show a bronzing of the foliage accompanied by distortion and twisting of the leaves. Growing points may die and plants may be stunted. This condition is caused by the activities of a tropical white mite, *Hemitarsonemus latus* Banks. Although the mite is too small to be seen with the unaided eye, the symptoms (which also occur on other solanaceous plants) are quite distinctive and recognizable. To control this problem, seedlings should be grown in noncontaminated areas. Commercial miticides recommended for the particular locale should be applied as soon as infection is discovered.

Fruit rots have been seen occasionally in Puerto Rico and could limit pepper cultivation in some cases. One common problem has been sunscald, which results in a change of color, necrosis, and finally a rot caused by secondary pathogens that affect the side of a fruit exposed to the sun. This condition is best controlled by using varieties that produce abundant foliage that shelters the fruit from the sun. Fruits exposed to the sun should be picked prematurely to avoid scald.

Bacterial wilt caused by *Pseudomonas solanacearum* Erw. F. Smith is sometimes a serious pest. When bacterial wilt occurs the lowermost leaves yellow and wilt. The roots of such plants appear normal, but are brownish inside, stems and roots ooze a dark liquid when cut and pressed, and the plants will eventually die. If bacterial wilt is found, it is very important to restrict its spread by not moving infected plants from one area to another. Bare-root seedlings are sometimes soaked in antibiotic solution to reduce the chance of infecting the planting site. Good drainage of the planting also helps slow down the disease.

Because this bacterium persists many years in the soil, it should be avoided by crop rotation. Infected soils should not be planted with solanaceous crops for 7 years or more (although other crops can be grown there). But the most important control measure is the use of resistant varieties such as the Guadeloupe cultivar 'Antibois'.

Another important disease related to bacterial wilt is bacterial leaf spot caused by *Xanthomonas vesicatoria* Dowson. This organism causes small wartlike elevations to form on leaves and fruit. Other organisms may enter these infections and destroy the fruit completely. Severe infections, especially during

is then somewhat restricted to its own block of soil. If held for several days the injured roots heal, and plants are better able to withstand transplanting shock.

Seedlings established in furrows and uprooted before transplanting directly in the field are subject to severe shock when planted. They can, however, be sprayed four or five times during the two weeks before transplanting with a 10 percent solution of sugar, which increases their resistance to planting shock. Also, planting should be managed on as cool a day as possible, or during the cool part of the day. Plants to be bare-root transplanted should be watered heavily 12 to 24 hours before transplanting so that the soil is damp and loose. (Watering just before transplanting usually makes a messy job.) Immediately after transplanting, the plants should be thoroughly watered again. A starter solution (5 to 8 grams of soluble fertilizer per liter of water), applied at the rate of 200 milliliters per plant, is very useful at this time. Spacing in the field may vary considerably. One meter between rows and 25 to 50 centimeters between plants within the row (depending on size of the plants expected) are convenient distances.

Postplanting Care

Peppers need a moderate amount of water, which can be supplied by rains or irrigation. They should not be overwatered. Weed control is usually a problem. Mechanical weed control, by tractor, animal-drawn implement, or hoe, should cut only shallowly into the ground. Weeds are easier to control when plants are established in furrows than when grown on ridges because the furrows tend to fill with soil during cultivation, burying small weeds. Mulching, which helps retain soil moisture as well as protect against weeds, is an accepted alternative when materials are inexpensive. Since legal restrictions on herbicides vary from place to place, farmers must find out local regulations before using these substances.

For maximum yields, further fertilization is desirable, but recommendations in the literature are confusing. The amount and proportion of fertilizer needed varies from region to region; soils may already contain some nutrients, making it impossible to specify exact requirements without soil tests. In Brazil (*9*), yields increased when potassium and phosphorus were increased steadily from 200 to 600 kilograms per hectare and decreased when nitrogen was added. But in Sri Lanka (*7*), yields were increased by adding nitrogen and were not increased by potassium and phosphorus. Highest yields were obtained when the nitrogen was split into five applications through the season of growth. In

CULTIVATION

Life Cycle

The life cycle of the peppers is simple. Seeds germinate in 6 days to 2 weeks. The young seedlings are rather slow to establish themselves, and thus peppers are frequently planted directly in boxes or flats and are then transplanted. In cases where a high level of technology can be applied, peppers can be seeded directly in the field. Flowering begins as soon as 6 weeks after seeding and is continuous for the life of the plant. The life span for some determinate paprikas is very short, because all fruits mature at nearly the same time and further development is limited. Extremely long-lived varieties may continue to fruit for 2 years. Most bell peppers and the temperate varieties of pungent peppers have a useful life of about 4½ months.

Aging of most peppers is associated with disease. Where plants are kept disease and pest free and well fertilized, they can be maintained almost indefinitely. Old plants that have lost most of their leaves are no longer productive and are usually destroyed before they die naturally. At the end of their life cycle, plants should be completely destroyed by plowing, burning, or composting.

Climatic and Soil Requirements

Peppers are warm-season crops that can be grown at any time of the year in the hot, humid Tropics. Nevertheless, the best yields in Puerto Rico have been obtained from June plantings (*5*). Peppers are day-neutral, or almost so, and thus appear about the same throughout the year. Peppers grow best where rainfall is moderate, or under dry conditions if irrigated. But many varieties can be grown during monsoon seasons when no tomatoes can survive. Most peppers do not fruit well when night temperatures are high, but the variety 'Allbig' resists damage.

Peppers can be grown in any soil and at a wide range of pH values, although they prefer a fertile, loamy soil. Peppers cannot grow well if their roots are constantly flooded. When very wet weather is expected, plants are established on ridges and during dry seasons they are sometimes planted in furrows.

Soil Preparation and Planting

For peppers to grow rapidly the soil should be plowed to a depth of 25 to 30 centimeters at least once. In intensive com-

the plant for long periods without spoilage. Some determinate peppers whose fruits mature almost simultaneously have been developed (fig. 5).

In the United States, major pepper-breeding programs are in progress in Florida, Texas, Louisiana, Georgia, Alabama, and California. Much breeding and genetic work is done in India, Brazil, Europe, and Japan.

VARIETIES

There must be thousands of varieties of peppers, and many have only local names and are restricted in distribution. The bell peppers that are bred for stuffing and for use uncooked in salads have long been represented chiefly by two varieties, 'Yolo Wonder' and 'California Wonder', which produce large, thick-walled fruits. But there are many other varieties with similar fruits and varying degrees of virus resistance. Some of these are 'Allbig', 'Burlington', 'King of North', 'Keystone', 'Oakview Wonder', 'Penn Wonder', 'P.R. Wonder', 'Pepperoncini', 'Resistant Giant', 'Ruby King', and 'World Beater'. Two varieties recently released from Florida, namely 'Florida VR-2' and 'Delray Bell', are resistant to three virus diseases, and an earlier variety from the same program, 'Yolo Y', is resistant to two viruses. The variety best suited for any particular area must be determined by trial.

Bell peppers that are slightly pungent when used red are called pimentos. A standard variety is 'Truhart Perfection'. Paprikas are sweet or slightly pungent and are often heart shaped. (Spanish paprikas are not pungent.) Sweet peppers that are neither bell nor paprika types include 'Long Red', 'Sweet Neapolitan', 'Cherry', and 'Banana'.

The pungent varieties are much more numerous and less distinct, and their names often refer to a type rather than a true variety. These rather general categories include chilis, cayennes, jalapenos, cherries, serranos, floral gems, and Santa Fes. Some of the named varieties in the United States are 'Cayenne', 'Long Red Cayenne', 'Tabasco', 'Red Chile', 'Serrano Chili', 'Gold Spike', 'Floral Gem', and 'Sport'. In the Philippines the perennial variety 'Pasites' is popular. 'Labayo' has ellipsoidal fruits. India has its own varieties identified by numbers. Some varieties that produce well in Puerto Rico are listed in table 2. Some are traditional or folk varieties while others are commercial.

TABLE 1.—*Some simple gene effects in pepper*

Dominant character	Recessive phase	Notes
Normal growth	Fasciculate or compact habit.	
Normal	Dwarf.	
Pubescence	Glabrous condition	2 genes.
Normal leaf	Filiform leaf.	
Normal leaf	Lanceolate leaves	1 or 2 genes.
Purple stems	Green stems	Incomplete dominance.
Purple flowers	White flowers	2 genes
Pendent fruit	Upright fruit.	
Oblate fruit	Elongate fruit.	
Pointed fruit	Blunt fruit	Incomplete dominance.
Bulging base	Nonbulging base.	
Short pedicel	Long pedicel.	
Green immature fruit	Yellow immature fruit.	
Red mature fruit	Yellow mature fruit.	
Pungency	No pungency.	
Male fertility	Male sterility	May be interaction with cytoplasm.
Virus susceptible	Virus resistances	Variable inheritance.
Bacterial spot resistance	Susceptibility	Another gene for resistance is recessive.

Source: Lippert et al. (*3*).

Genetics and Breeding

The fact that all peppers are diploids (2x = 24 chromosomes) and all can be grown as annuals has made considerable progress in the genetics and breeding of these species possible (*4*). Some progress has been made on identifying individual chromosomes, and many of the simpler inherited characters that affect almost all distinguishable differences among varieties have been described. Trisomic races are being used to associate genes with particular chromosomes (*6*). Some of the most evident of these traits are given in table 1.

Peppers are normally self-pollinated, but anthers do not dehisce until after anthesis. Cross-pollination by bees and other insects can reach 40 percent but is normally less than 5 percent.

A major problem in pepper breeding has been developing varieties resistant to viruses and other diseases. Since at least six viruses (some of which have several strains) attack peppers, untangling the complicated pathogenic and genetic relationships has been difficult. Virus-resistant varieties have been developed, but because of the wide variety of diseases and growing conditions there is still much to do. Another disease for which

FIGURE 3.—Cherry pepper plant.

Origin and Distribution

Peppers are all of New World origin. Dried pods found in tombs in Peru suggest that peppers have been used for thousands of years. The center of the common species, *C. annuum*, is Mexico. The minor species, *C. frutescens*, is widely distributed in tropical and subtropical America.

Peppers were spread throughout the Old World shortly after the discovery of America. They were adopted widely and are now indispensable in India. Although the sweet or only slightly pungent forms are preferred in the United States and Europe, the very pungent peppers are the most widespread and economically important.

Description

Capsicum annuum plants are annuals or short-lived perennials grown as annuals, with the form of an herb or herbaceous shrub, usually erect but sometimes almost prostrate. Growth is normally indeterminate, but rapidly maturing determinate varieties have also been developed.

Peppers have strong taproots, which when injured, give rise to vigorous, fibrous root systems. The stems are fleshy, sometimes slightly woody at the base, and round or slightly angular in cross section. The stem is very much branched. Two

FIGURE 1.—Various pepper forms.

BOTANY

Taxonomy and Nomenclature

Peppers are members of the family Solanaceae, a very large family chiefly of herbaceous plants, that is spread throughout the Tropics and to a lesser extent, the Temperate Zone. The family includes numerous species with edible fruits, and some with edible leaves. Common edible species include the potato, tomato, and eggplant.

The genus of the peppers, *Capsicum* (from box or case), consists of 90 or more species (according to the classifications used), of which four to six are cultivated. Cultivated and wild species are described by Lippert et al. (*4*) and by Heiser and Smith (*3*). There are taxonomic controversies, but for practical purposes, most of the desirable peppers are found in one species, *Capsicum annuum* L. Some forms of *C. frutescens* L. are used for their small and very pungent fruit in hot sauces but the species is of relatively minor importance. Two other species (*C. pubescens* Ruiz & Pav. and *C. pendulum* Willd.) are cultivated but are grown only on a small scale.

CONTENTS

ILLUSTRATIONS

TABLES

This publication is available from the Mayagüez Institute of Tropical Agriculture, Science and Education Administration, P.O. Box 70, Mayagüez, P.R. 00708.

Other publications in this series:

Part 1. The Winged Bean.
Part 2. Okra.
Part 3. Chaya.
Part 4. Sponge and Bottle Gourds.
Part 5. Eggplant.
Part 6. Amaranth and Celosia.

Published by Agricultural Research (Southern Region)
Science and Education Administration
U.S. Department of Agriculture
New Orleans, La. 70153

U.S. DEPARTMENT OF AGRICULTURE
SCIENCE AND EDUCATION ADMINISTRATION
P. O. BOX 53326
NEW ORLEANS, LOUISIANA 70153

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U. S. DEPARTMENT OF
AGRICULTURE
AGR 101